SEQUENCE STRATIGRAPHIC INTERPRETATION AND MAPPING, NEW JERSEY MARGIN

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LONG-TERM GOALS

This project forms part of a long-term effort, linked to ONR's STRATAFORM program, to document the evolution of the middle Atlantic continental shelf and slope, offshore New Jersey, at a variety of spatial scales (lateral and vertical) and in three dimensions (3-D; Austin et al., 1996; 1997). The overall goal is to determine how short-term geological processes contribute to the formation of the preserved record of depositional sequences.

SCIENTIFIC OBJECTIVES

Depositional sequences are unconformity-bounded packets of sediment that are the building blocks of sedimentary deposits. They form in response to fluctuations in geological and environmental conditions, notably global sea-level (eustasy). We have delineated the 3-D geometries of Miocene clinoform sequences in order to investigate: 1) whether known, rapid Miocene shelf progradation occurred predominantly in response to point sources of sediment or to distributed cross-shelf sediment transport; 2) paleo-water depths at Miocene clinoform breakpoints, crucial to eustatic amplitude estimates and for understanding processes of sediment delivery to clinoform slopes during periods of rapid progradation; 3) the origins and spatial distribution of canyons during the Miocene.

APPROACH

A great deal of oil-industry multichannel seismic (MCS) data was acquired on the middle Atlantic margin beginning in the mid-1970s, when leasing there commenced. We selected a grid of 36-fold MCS data shot by Digicon in 1975, encompassing ODP sites on the slope and mid-outer shelf (Figure 1). We acquired the seismic profiles in digital form on magnetic tape in order to interpret and map the upper (seafloor - 1 sec.) interval using GeoQuest seismic interpretation software. While not true 3-D data, the dense grid allows mapping of the 3-D evolution of elements of the shelf sediment prism at the scale of individual sequences (i.e., vertical thickness • 100 m, horizontal dimensions of a few km to several tens of km).

WORK COMPLETED

The data tapes were not in SEGY format and some had deteriorated or been damaged (some data bits in both traces and trace headers were degraded). Software was therefore developed to convert the data to SEGY format and renumber common-depth points. Sequence boundaries approximately correlative with four slope reflections dated by ODP Leg 150 (m3, ~13.6 Ma; m2, ~12.5 Ma; m1, ~11.0 Ma; m0.5, ~8.0 Ma) have been mapped across the northern portion of the grid in a region extending ~70 km along strike and ~50 km down-dip (Figure 1; Fulthorpe and Austin, in press). This is the area of most immediate relevance to STRATAFORM objectives, linking: 1) ODP slope and shelf sites (Legs 150 and 174A), 2) 1993 UTIG Huntec 2-D/3-D survey, 3) MCS and SCS data acquired in support of Leg 150, and 4) 1995 MCS regional and hazards surveys acquired for STRATAFORM (Figure 1).

RESULTS

Miocene clinoform breakpoints are linear to gently arcuate in plan (Figure 2). A bulge in the margin migrated southward during deposition of successive clinoforms suggesting a progressive increase in volume of

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sediment from southern sources relative to those in the north during the period ~13.6 to ~8. Ma. Miocene canyons were rare: only one V-shaped clinoform slope canyon was recognized. Mapping also confirmed the existence of rare planar-floored canyons seaward of clinoform toes. V-shaped and planar-floored canyon geometries are indicative of separate depositional histories. The lack of evidence for canyons breaching clinoform breakpoints suggests that Miocene rivers did not discharge directly at paleo-shelf edges during progradation. Comparison of reconstructed paleo-elevations of Miocene breakpoints with the Exxon eustatic curve supports the view that m3, m2 and m0.5 were not exposed during lowstands, though m1 may have lain close to sea level.

IMPACT/APPLICATIONS

Sequence stratigraphic models have assumed that sea level fell to, or below, the clinoform breakpoint at lowstands, so that sediment could be delivered directly to the slope. Our results, however, suggest that Miocene river mouths were generally located landward of breakpoints throughout each sea-level cycle. If correct, shelf sediment transport processes must have controlled both progradation and the efficient lateral dispersal of sediment and muting of point-source effects indicated by the near-linear breakpoint trends. In addition, paleo-water depth estimates at m3, m2 and m0.5 suggest that elevations of corresponding lowstands on the Haq et al. (1987) eustatic curve may be too high by several tens of meters.

TRANSITIONS

The mapped clinoforms will be the subject of a numerical modeling effort by G. Karner of Lamont-Doherty Earth Observatory.

RELATED PROJECTS

This work has close links to ODP drilling on the New Jersey margin. Fulthorpe participated in both Leg 150 (slope) and Leg 174A (shelf) and Austin was co-chief scientist of Leg 174A.

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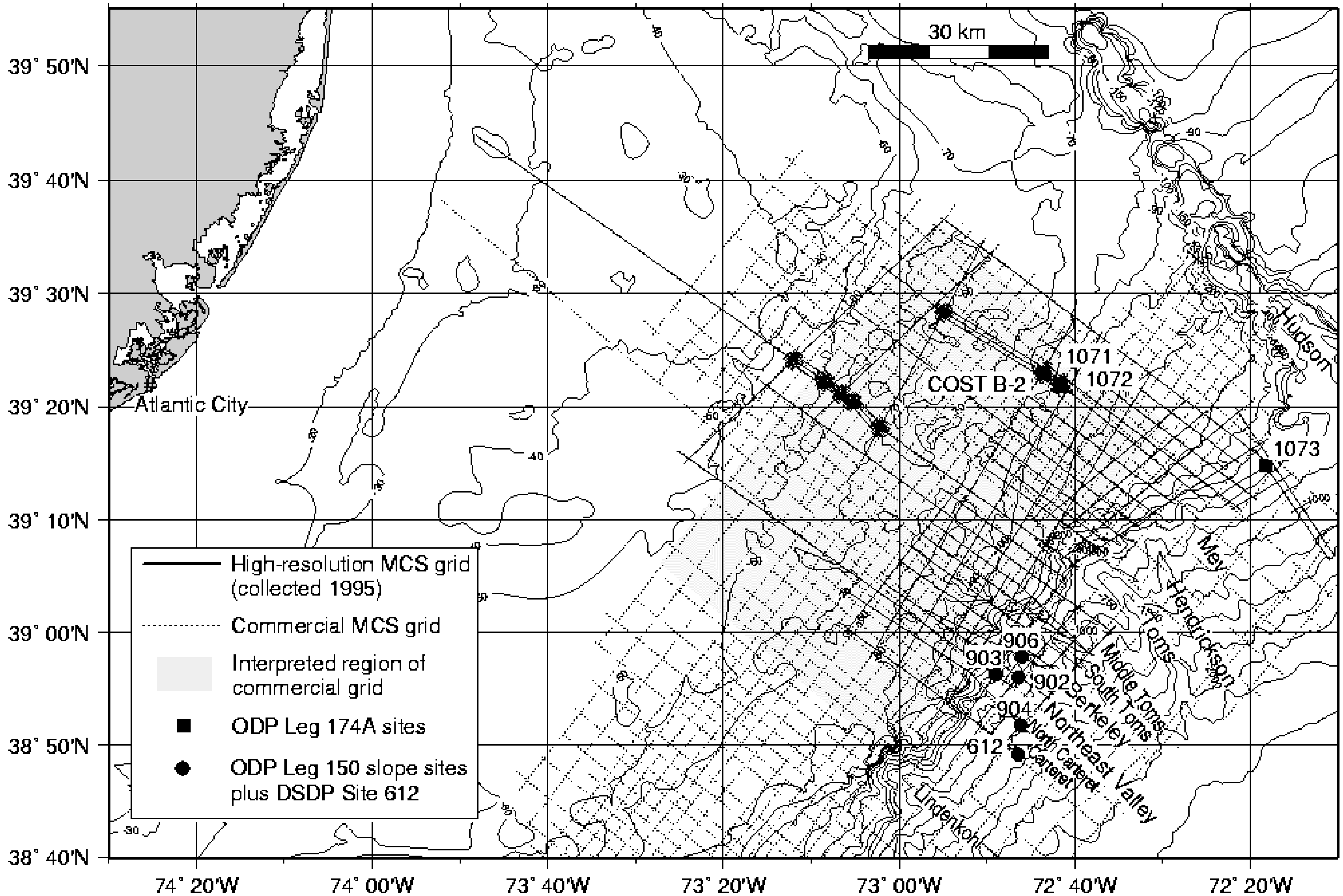
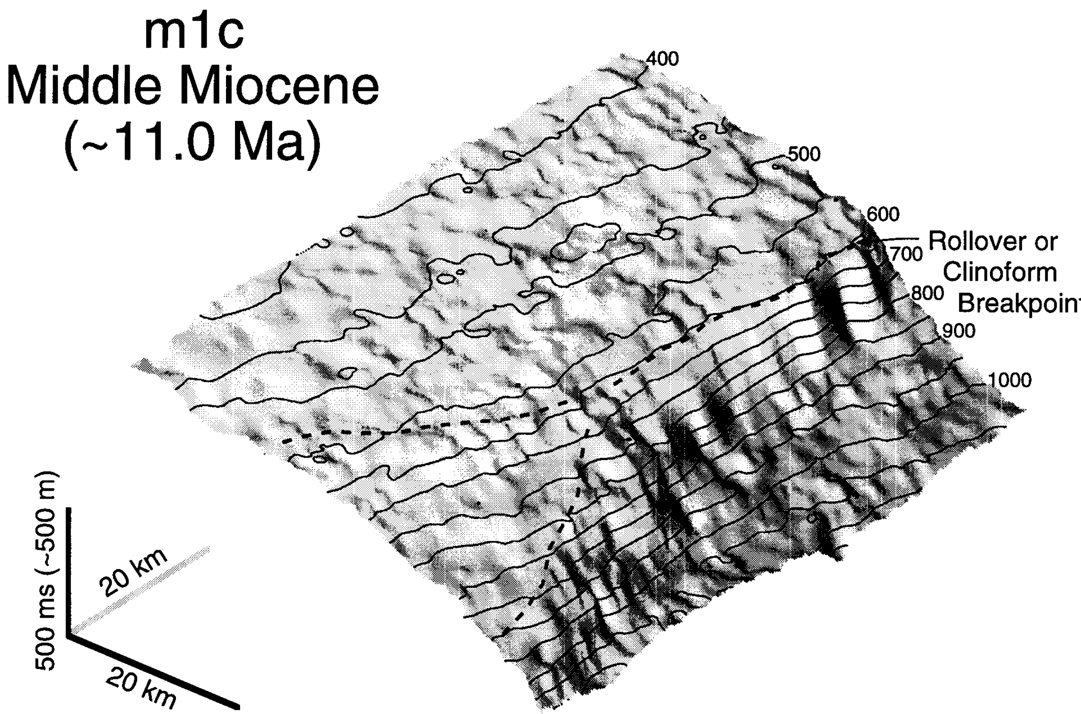


Figure 1. Bathymetric map showing locations of commercial seismic grid, including interpreted area of mapped Miocene clinoforms in the subsurface. Also shown are: a high-resolution MCS survey grid collected in 1995 for STRATAFORM, and locations of existing ODP Middle Atlantic Transect (MAT) sites drilled on Legs 150 and 174A, plus DSDP Site 612 (Leg 95). The COST B-2 well is approximately coincident with Site 1071.



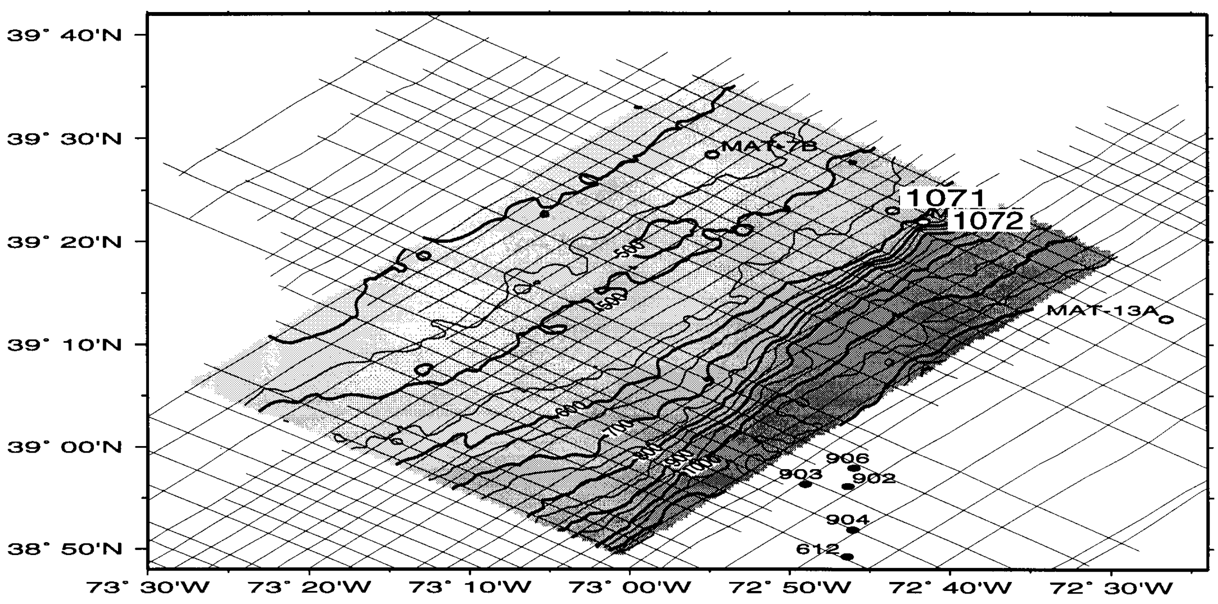


Figure 2. Buried clinoform m1c (middle Miocene, ~11.0 Ma). Lower: structure map showing seismic grid (Figure 1), existing drill sites 1071, 1072 (ODP Leg 174A), 902-904, 906 (ODP Leg 150), 612 (DSDP Leg 95), and additional proposed MAT drill sites. Units are milliseconds two-way traveltime below present sea level. Upper panel: 3-D perspective shaded image with traveltime contours (azimuth of artificial illumination = 220°). Both panels are viewed from an azimuth of 180° and an elevation of 30°. The rollover, or clinoform breakpoint, bifurcates in the southern part of the mapped area. Clinoform slope canyons are absent, but gullies may be present at the limits of seismic resolution.